ECE 595

M02B-CELLULAR NETWORK EVOLUTION

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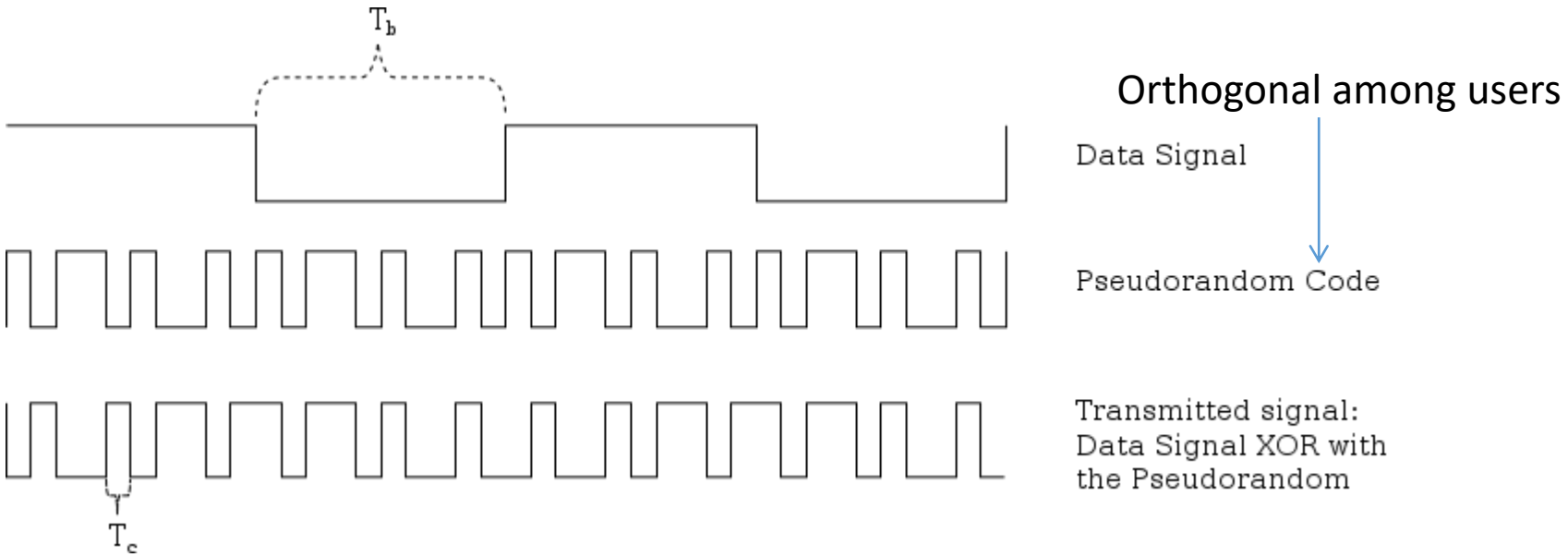
❑ Code Division Multiple Access (CDMA)

- ➢ Use of orthogonal codes to separate different transmissions
- ➢ Each symbol of bit is transmitted as a larger number of bits using the user specific code – Spreading
  - ✓ Spreading bandwidth is much greater than the original signal bandwidth
  - ✓ But all users use the same frequency band together



Example of CDMA in downlink

- Assume that there are three MSs, i.e., A, B, and C. The spreading codes for the three mobile users are:
  - ✓ C_A=(1,1,1,1,1,1,1,1)
  - ✓ C_B=(1,-1,1,-1,1,-1,1,-1)
  - ✓ C_c=(1,1,1,1,-1,-1,-1,-1)
- If the base station tries to send "0" to A, "1" to B, and "0" to C, what kind of signal will be transmitted in a channel?
- How do the MSs recover the data from the received signals?

❑ How to generate spreading codes

- Walsh Codes are most used in generating orthogonal codes for CDMA.
  - ✓ For a set of Walsh codes of length n, it consists of n lines to form a square matrix of n × n Walsh codes.
  - ✓ Each line in the square matrix is orthogonal to another line.

- How to generate the square matrix?

$$H_{2n} = \begin{bmatrix} H_n & H_n \\ H_n & \overline{H_n} \end{bmatrix}$$

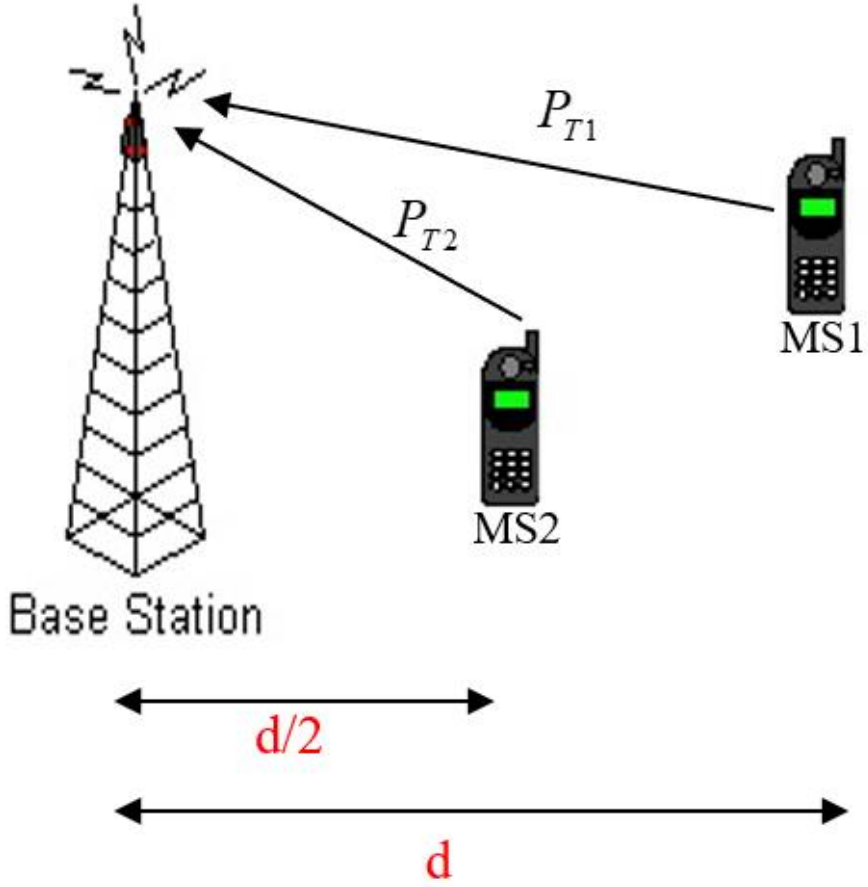
  - ✓ H_n is the square matrix of n × n Walsh codes.
  - ✓ $\overline{H_n}$ complimentary of H_n (switching 1 and -1).

$$\mathbf{H}_1 = [1]; \quad \mathbf{H}_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix};$$

$$\mathbf{H}_4 = \mathbf{H}_2 \otimes \mathbf{H}_2 = \begin{bmatrix} \mathbf{H}_2 & \mathbf{H}_2 \\ \mathbf{H}_2 & -\mathbf{H}_2 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

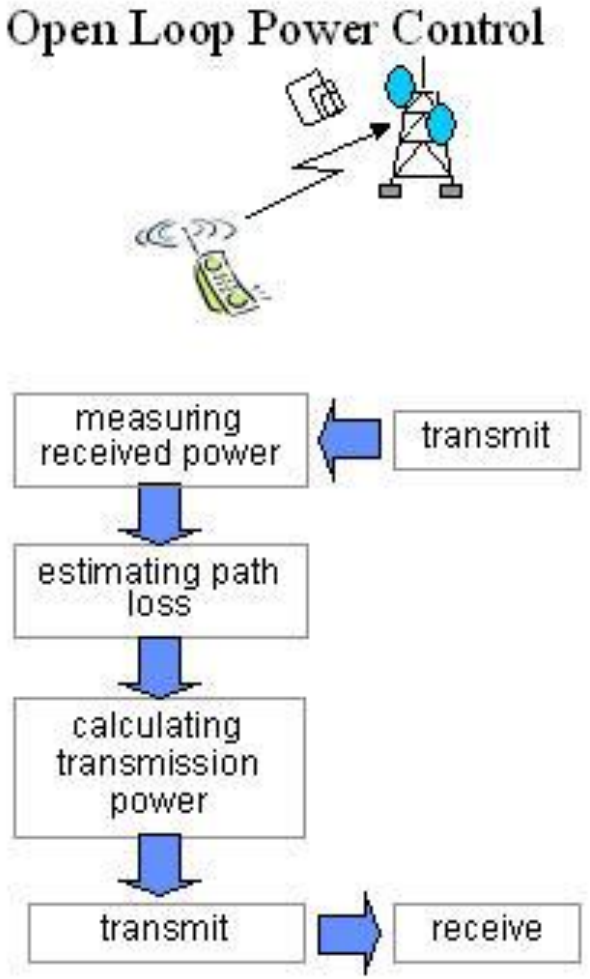
Apply CDMA in uplink

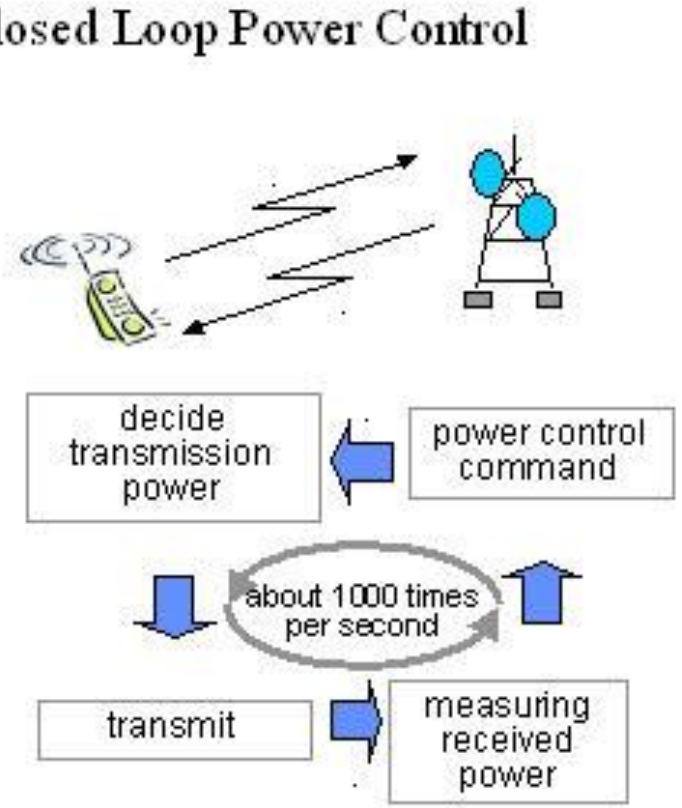
- In CDMA uplink, multiple MSs may transmit the spread signals at the same time. The received power at the base station for all MSs should be close to each other.
- However, CDMA incurs near-far problem
  - ✓ MSs near the base station have high received power.
  - ✓ MSs far from the base station have low received power.
- Power control: enables MSs to adjust power when they transmit signal in order to ensure the base station receives all the signals at the appropriate power.



Apply CDMA in uplink

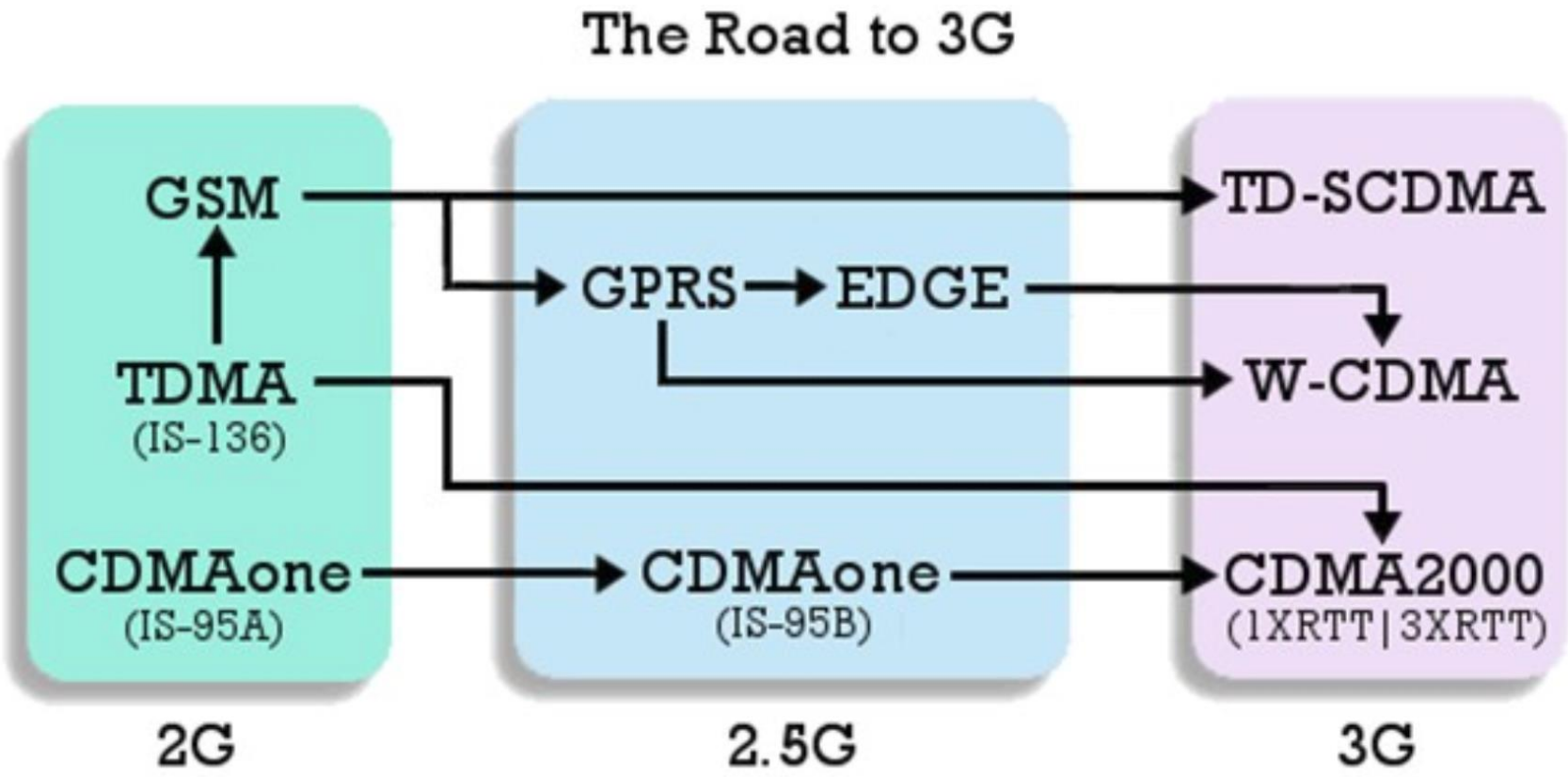
- Power control





3rd Generation (3G)

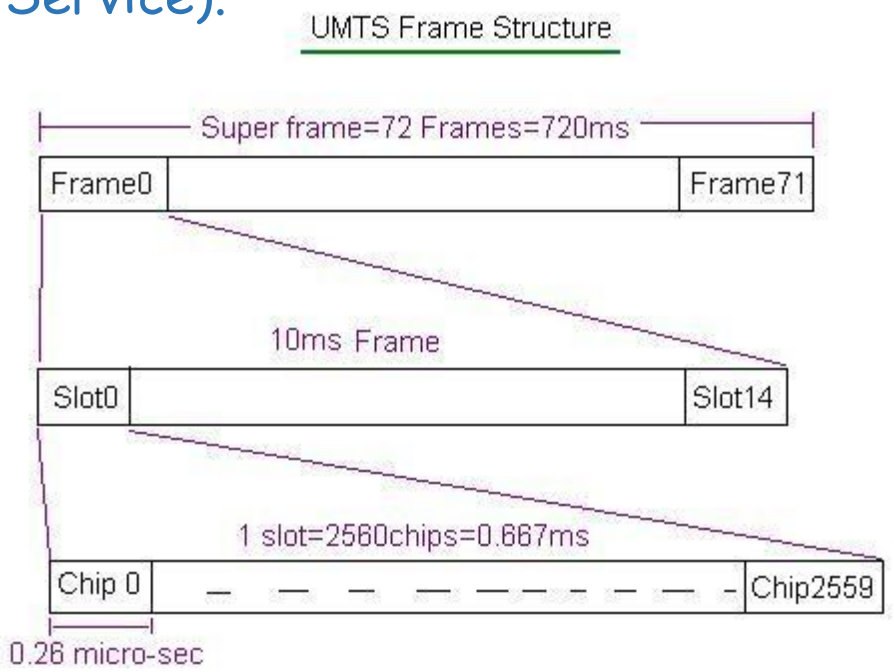
❑ 3G Evolution Path



3rd Generation (3G)

❑ WCDMA (Wideband-CDMA)

- ✓ WCDMA is the main third generation air interface.
- ✓ 3G network is also called UMTS (Universal Mobile Telecommunications Service).

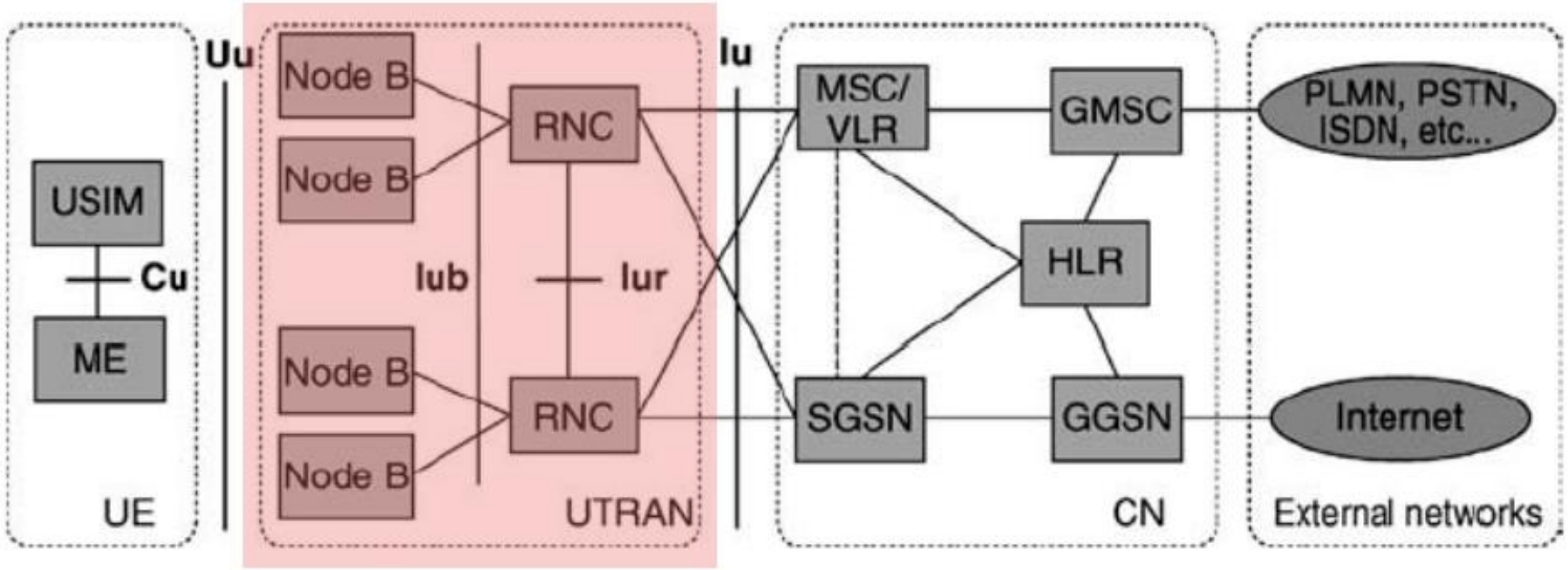


Carrier Spacing	5 MHz (nominal)
Chip Rate	3.84 Mcps
Frame Length	10 ms (38400 chips)
No. of slots/frame	15
No. of chips/slot	2560 chips (Max. 2560 bits)
Uplink SF	4 to 256
Downlink SF	4 to 512
Channel Rate	7.5 Kbps to 960 Kbps

3rd Generation (3G)

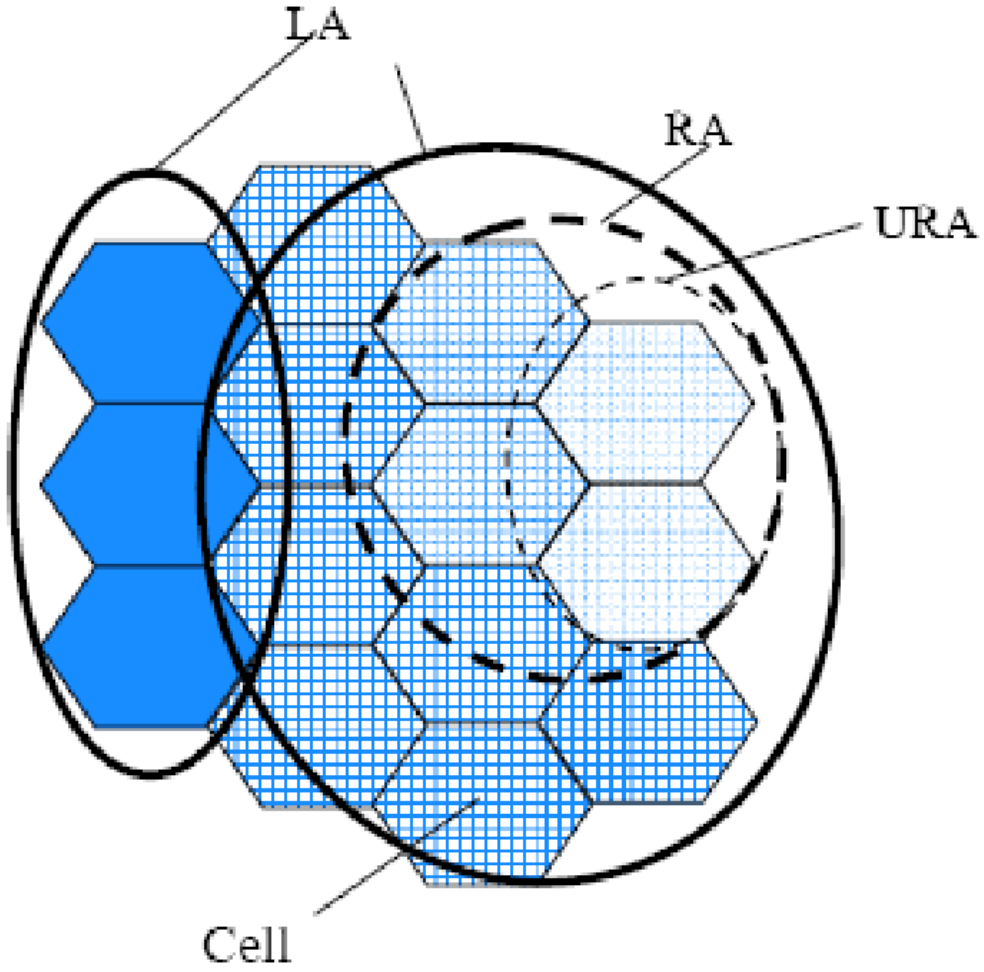
❑ 3G system overview (Universal Mobile Telecommunications Service-UMTS)

- ➢ UTRAN (UMTS Terrestrial Radio Access Network)
  - ✓ NodeB: CDMA-based BTS
  - ✓ Radio Network Controller: control radio resource in its domain, similar with BSC



❑ UTRAN Registration Area (URA)

- An area coverer by a number of cells



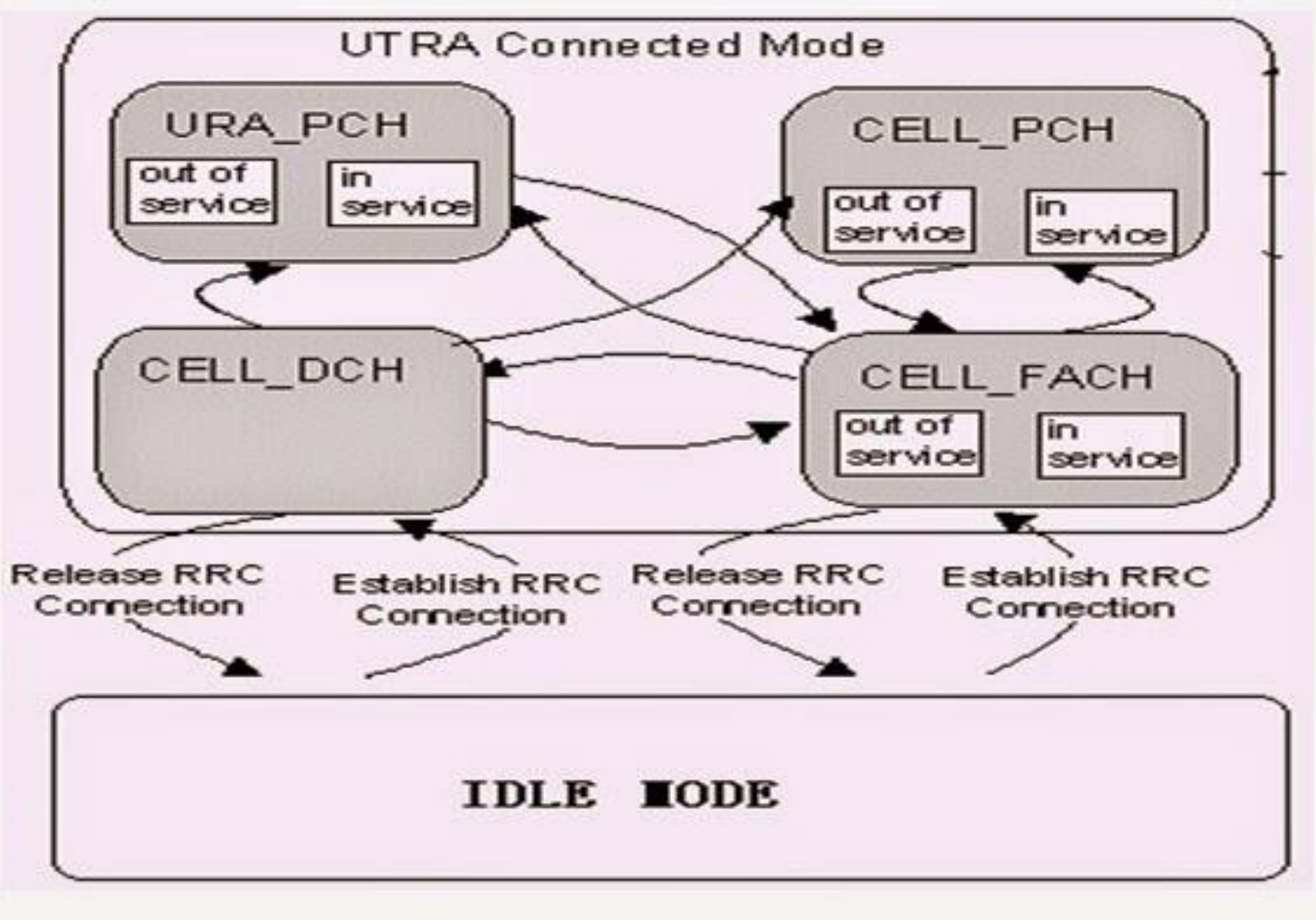
UE working mode

- Two basic working modes
  - ✓ Idle
    - UE stands by without any data service. There's no connection between UE and URAN
  - ✓ Connected
    - UE transferred to the connected mode after accomplishing RRC (Radio Resource Control) connection setup
    - There are 4 states under the connected mode
      - Cell-DCH (dedicated channel)
      - Cell-FACH (Forward Access Channel)
      - Cell-PCH (Paging channel)
      - URA-PCH (UTRAN Registration Area Paging Channel)

UE working mode

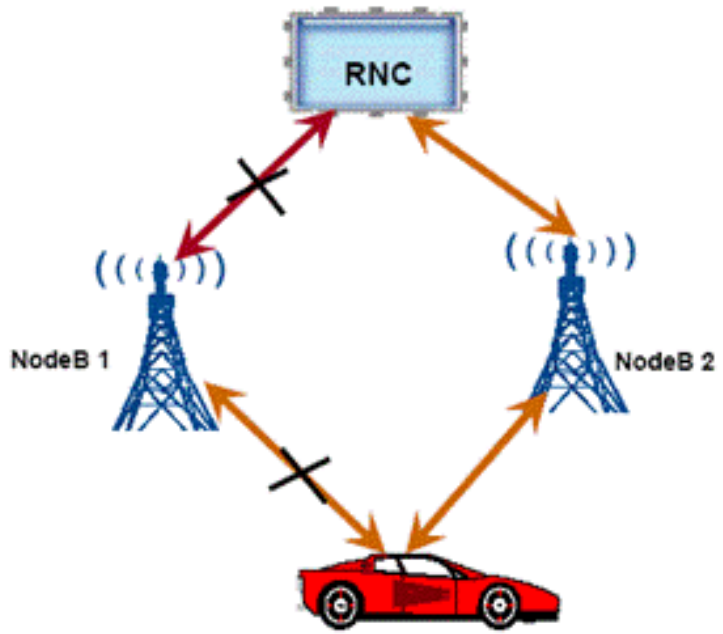
- CELL-DCH
  - ✓ A dedicated link is set up to enable the UE to transmit/receive a large volume of data or voice calls
  - ✓ UTRAN knows exactly which cell the UE is in
- CELL-FACH
  - ✓ There is some but not too much data, and so there's no need to assign a dedicated channel to the UE.
  - ✓ UTRAN knows exactly which cell the UE is in
- CELL-PCH
  - ✓ There is no data related to the UE, but the UE have to listen to the page channel (PCH) for paging information.
  - ✓ UTRAN knows exactly which cell the UE is in
- URA-PCH
  - ✓ There is no data related to the UE, but the UE have to listen to the page channel (PCH) for paging information.
  - ✓ UTRAN knows exactly which URA the UE is in

UE working mode



Handoff

- Hard handoff (break before make)
  - ✓ The UE communicates with only one NodeB
  - ✓ Connection with the old NodeB is broken before the new NodeB connection is established.



❑ Handoff

➢ Soft handoff (make before break)

- ✓ The UE communicates with more than one NodeBs .
- ✓ When a call is in a state of soft handover,
  - in the downlink scenario, the UE will combine all the signals from the NodeBs.
  - in the uplink scenario, the RNC may compare the signals from different NodeBs frame-by-frame, and select the best candidate after each interleaving period.